Zentrum für Entwicklungsforschung
Center for Development Research
University of Bonn

ZEF-Discussion Papers on
Development Policy No. 191

Matthias Kalkuhl

How Strong Do Global Commodity Prices Influence Domestic Food Prices in Developing Countries? A Global Price Transmission and Vulnerability Mapping Analysis

Bonn, May 2014

Matthias Kalkuhl, How Strong Do Global Commodity Prices Influence Domestic Food Prices in Developing Countries? A Global Price Transmission and Vulnerability Mapping Analysis, ZEF-Discussion Papers on Development Policy No. 191, Center for Development Research, Bonn, May 2014, pp. 35.

ISSN: 1436-9931

Published by:
Zentrum für Entwicklungsforschung (ZEF)
Center for Development Research
Walter-Flex-Straße 3
D – 53113 Bonn
Germany
Phone: +49-228-73-1861
Fax: +49-228-73-1869
E-Mail: zef@uni-bonn.de
www.zef.de

The author:
Matthias Kalkuhl, Center for Development Research (ZEF). Contact: mkalkuhl@uni-bonn.de

Acknowledgements

I am greatly indebted to Felix Baquedano for his valuable comments and suggestions on the econometric model as well as the representation of the findings. I further thank Mekbib Haile, Manuel Hernandez, Lukas Kornher and Miguel Robles for their useful comments on an earlier version of this paper. I am grateful to Mikko Bayer, David Schaefer and Christian Zimpelmann for building and enhancing the database on international and domestic food and commodity prices. We thank the FAO GIEWS team and FEWS.NET for providing price data on commodities in developing countries. Financial support from the Federal Ministry for Economic Cooperation and Development (BMZ) and Union Investment is gratefully acknowledged.

Abstract

This paper analyzes the transmission from global commodity to domestic food prices for a large set of countries. First, a theoretical model is developed to explain price transmission for different trade regimes. Drawing from the competitive storage model under rational expectations, it is shown that domestic prices can respond instantaneously to global prices even if no trade takes place but future trade is expected. Using a global database on food prices, we construct national and international grain price indices. With an autoregressive distributed lag model, we empirically detect countries in which food prices are influenced by global commodity prices, including futures prices. Mapping transmission elasticities with the size of the population below the poverty line which spends typically a large share of its income on food, we are able to estimate the size of vulnerable population. Our empirical analysis reveals that 90 percent of the global poor (income below 1.25$/day) live in countries where domestic food prices respond to international prices - but the extent of transmission varies substantially. For 360 million poor people, international prices transmit to their country at rates of 30 percent or higher within three months.

Keywords: time series econometrics, poverty, trade, storage, market integration, volatility, shocks, price indices

JEL classification: C22, E3, F1, F6, Q1

1 Introduction

The unexpected price spikes in 2007/2008 and again in 2010 for major global food commodities raised serious concerns on the impact of global price shocks and volatility on food security in developing countries. There have been several attempts to investigate the impacts of price shocks on income and poverty as well as nutrition indicators. Some of these papers quantify the number of people who were pushed below the poverty line due to increased food prices (and decreased real incomes) by 105-150 million (de Hoyos and Medvedev, 2011; Ivanic and Martin, 2008); Tiwari and Zaman (2010) estimate that 63 million became food insecure, measured by the number of people who consume less than 1,810 calories/day. As these works, however, use either domestic food prices where the linkage to global prices is not directly clear (de Hoyos and Medvedev, 2011) or ad-hoc assumption on a uniform price transmission from global markets (Ivanic and Martin, 2008; Tiwari and Zaman, 2010), they cannot provide a satisfactory answer on the impacts of global price shocks. The heterogeneous degree of price transmission from international to domestic markets has to be considered explicitly for ex-post impact analysis as well as early warning and information systems that aim to identify upcoming food security risks.

There is some controversy about the role of international commodity prices for local food security in developing countries. A wide-spread argument for the low integration of developing countries, in particular African countries, into global markets is that many of them import only small amounts of the commodity they consume and trade is furthermore not continuously taking place. Additionally, transaction costs due to transportation costs and trade barriers like tariffs and quotas are considered to reduce price transmission. Existing research has therefore come to different conclusions regarding the degree of price transmission, depending on the considered domestic market, crop and international reference price.

So far, a comprehensive analysis which focuses on the extent of transmission for the world-wide 1.2 billion people living below the poverty line is missing: Neither do we have an estimation of how many poor people are affected by global-market induced food price changes nor do we know the heterogeneous extent of price transmission. While the recent FAO report on the State of Food Insecurity in the World (FAO, 2013) attempted to provide an aggregated picture of the extent of price transmission, it used regionally aggregated food price indices which showed only weak linkages to global prices and price volatility.[1] The use of regionally aggregated price indices masks, however, the heterogeneity of countries and commodities: combining prices from markets with high market integration and low (or missing) market integration will give an average low transmission that distracts from the serious impacts of international price shocks for *some* markets.

This paper aims to fill this gap by providing a globally comprehensive but nationally differentiated analysis of price transmission which maps transmission elasticities to the size of the vulnerable population. The result will be a Lorenz-type curve showing how many poor people are how strongly affected by international price shocks. The paper also provides a pragmatic way to deal with the heterogeneity of local food staples by creating a domestic grain price index which is of high relevance for the poor and vulnerable population. Our grain price index is preferable to the food price indices from national statistical agencies used in FAO (2013), Cachia (2014) and Ianchovichina et al. (2012) because the latter often contain processed and luxury food items that are of little relevance for the poor. As for these products material costs play a minor role, using official food price indices will likely underestimate the degree of price transmission on the costs of the food basket of poor people. Contrary, using individual crop prices instead of price indices – as done by most existing studies – inflates the reported results of the empirical analysis, neglects possible substitution effects between grains and complicates interpretation on the severity of price transmission.

The question on market integration of developing countries is of high relevance for policy makers and international organizations. Market integration has both opportunities and risks. The larger a market is, the better its capability to diversify (uncorrelated) shocks which has a general tendency to stabilize prices with benefits for producers as well as consumers. In contrast, integration into global markets makes domestic markets vulnerable against 'external' shocks that are beyond the control of the national government, in particular, international price volatility (Kornher and Kalkuhl, 2013). Market liberalization may further be inconsistent with domestic price stabilization schemes such as buffer stocks.

[1] Cachia (2014) provides a more detailed overview on methods and data on regional price transmission.

In this paper, we do not attempt to assess the costs and benefits of market integration. Leaving the normative debate aside, we address the descriptive question of the extent of market integration which forms the base for further normative analyses – but also for an appropriate impact assessment of global price shocks. Mapping price transmission with vulnerable population will be one important step for a better understanding of the impacts of recent global food price spikes since 2007. Additionally, our mapping analysis helps to identify crucial international reference prices that should be monitored carefully within early warning and food security information systems. Finally, the calculated transmission elasticities can be used for forecasting the partial effect of international commodity price dynamics on local food prices and, thus, food security.

The paper is structured as follows: Section 2 provides an overview on existing literature on price transmission and market integration. Section 3 establishes the theoretical framework by drawing on basic trade and storage models from the literature. This section in particular helps to explain price transmission when trade is (temporally) absent.[2] Section 4 describes the empirical model to estimate price transmission. Section 5 presents the price data used and the calculation of a domestic grain price index as alternative reference price for the costs of the food basket of the poor. Section 6 discusses the results of the transmission analysis, including some robustness checks for different specifications. Section 7 summarizes the findings and concludes with policy and research implications.

2 Existing Work on Price Transmission

In the wake of the large swings of international commodity prices, there has been various research on market integration and price transmission. Using staple prices for several Sub-Saharan African markets, Minot (2010) calculates that price increase in the region was on average 71% of the corresponding world market increase in 2007/2008. Because static correlations between prices might be spurious and no compelling evidence for market

[2] Götz et al. (2013) provide an analysis on the price transmission of Ukraine and Russia during different trade regimes. The authors find that price transmission was also present during times of tight export quotas and high export taxes but stronger during liberal trade regimes.

integration exists (Ravallion, 1986), Minot (2010) extends the correlation analysis by the application of a Vector Error Correction Model (VECM). This model, however, suggests that only one fifth of the considered domestic price series have a long-run relationship to international prices. The estimated price elasticities range from 16 to 97 percent. In general, rice prices seem to be more integrated than maize prices.

Robles (2011) estimates price transmission with an autoregressive distributed lag (ADL) model for some Latin American and three Asian countries using retail prices (Latin America) and wholesale prices (Asia) between 2000 and 2008. Transmission to processed food items is reported to be lower than to raw commodities. The average transmission from international wheat to domestic bread and pasta prices is 20 and 24 percent, respectively. In contrast, transmission of rice and wheat prices in Asia to the raw commodity prices varies a lot among the considered cities, but values higher than 50 percent are reported for several cities.

Using a similar econometric approach but considering food price indices instead of commodity prices, Ianchovichina et al. (2012) analyze price transmission to Middle East and North Africa countries. They report transmission for several countries in the range of 20 to 40 percent. Greb et al. (2012) attempt to investigate price transmission and draw some conclusions on the extent and determinants of market integration by assessing existing literature and by an own analysis based on FAO GIEWS price data. Within their meta-analysis, they find that rice markets are more integrated than maize markets. They report substantial price transmission (long-run price transmission coefficient of 75 percent).

Most recently, Baquedano and Liefert (2014) calculated short- and long-run transmission coefficients for several commodities in developing countries within a Single Equation Error Correction Model (SEECM). The authors find that most consumer markets in developing countries are co-integrated with world markets although the speed of the equilibrium adjustment is rather low. Cachia (2014) provides an overview over different concepts and models of price transmission and estimates market integrations and price transmission between the FAO (global) food price index and regionally aggregated food price indices (based on consumer price indices from national statistical agencies). His findings suggest limited market integration and rather slow transmission, which might be related to the use of aggregate food price indices as discussed above.

3 Theoretical Framework

Domestic prices are linked to world market prices primarily through trade. If the commodity is imported, the domestic price p_t^D equals the international pice p_t^G plus the transaction costs $\tau_t^{I,E}$ for import *I* and export *E*. Depending on the trade balance (a positive T_t denotes exports, a negative T_t imports), we can therefore distinguish the three cases (Samuelson, 1952):[3]

$$p_t^D = p_t^G + \tau_t^I \qquad \text{if } T_t < 0 \tag{1a}$$

$$p_t^D = p_t^G - \tau_t^E \qquad \text{if } T_t > 0 \tag{1b}$$

$$p_t^D = D(Q_t^D, Y_t^D) \qquad \text{if } T_t = 0, \tag{1c}$$

where $D(Q_t^D, Y_t^D)$ is the inverse of the domestic demand function which depends on demand Q_t^D and income Y_t^D. Equations (1a)-(1c) imply that the domestic price is independent from the global price if and only if it is not profitable to export nor to import the commodity, i.e. if

$$p_t^G - \tau_t^E < D(Q_t^D, Y_t^D) < p_t^G + \tau_t^I \tag{2}$$

Spatial arbitrage through trade links domestic and global prices immediately. There exists, however, also another form of arbitrage through storage which links current prices to expected (future) prices. Assuming rational expectations, current prices are a function of expected futures prices (Wright and Williams, 1991):

$$p_t = \beta E_t[p_{t+1}] \qquad \text{if } I_t > 0, \tag{3a}$$

$$p_t > \beta E_t[p_{t+1}] \qquad \text{if } I_t = 0, \tag{3b}$$

[3] In the subsequent theoretical analysis we will assume that all transaction costs are unit costs and independent to the price level p_t^G. Considering ad-valorem transaction costs ς_t^I, for example due to transport insurance, value-added tax or ad-valorem tariffs, Equation (1a) would change to $p_t^D = p_t^G(1 + \varsigma_t^I) + \tau_t^I$. As the ad-valorem component has no impact on the transmission elasticity (it cancels out after taking the derivatives) we omit it to shorten the formal analysis.

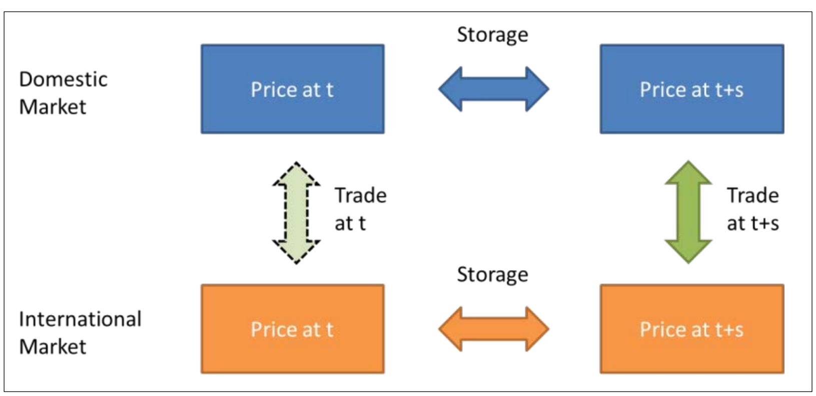
where p_t is the price of the commodity at time t; $\beta = (1-\delta)/(1+r)$ contains the interest rate *r* and rate of deterioration δ; $E_t[\cdot]$ refers to the expectation at time t; and I_t denotes the inventory of grains. When there are no inventories ($I_t = 0$), current and future prices are not directly linked through intertemporal arbitrage.

Consider now the case of a country which has a zero or negative trade balance (that may change over time) but which is never in an exporting state. Combining Equations (1a) and (3a) for the domestic and global markets and assuming positive storage on both, for exactly *s* consecutive periods without trade, we obtain:

$$p_t^D = \gamma^s p_t^G + [\beta^D]^s E[\tau_{t+s}] \qquad \text{if } I_{t+j}^{D,G} > 0, T_{t+j} = 0 \text{ for } 0 < j < s \quad (4)$$

where $\gamma := \frac{\beta^D}{\beta^G} = \frac{(1-\delta^D)(1+r^G)}{(1-\delta^G)(1+r^D)}$. Equation (4) indicates that domestic prices depend on global prices even when there is *no trade* in a sequence of *s* periods. If trade is expected in future periods (which brings domestic and global prices back to equilibrium) current domestic prices are adjusted according to intertemporal arbitrage. The relation between domestic and international markets for the direct trade regime and the indirect transmission regime (expected trade, with storage) is depicted in Figure 1.

Figure 1: Linkage between domestic and international prices through storage, trade and expectations



Source: own elaboration, based on Eq. (1)-(4).

In case of trade, prices at *t* are directly linked. In case of no trade at *t* but expected trade at *t+s*, prices at *t* are indirectly linked through storage and expected trade arbitrage.

Inserting (4) into the transmission elasticity $\eta \coloneqq \frac{\partial p^D}{\partial p^G}\frac{p^G}{p^D}$, we get:[4]

$$\eta = \frac{p_t^G}{p_t^G + [\beta^G]^s E[\tau_{t+s}]}$$

Building partial derivatives of η, we obtain $\eta'(p_t^G) > 0$, $\eta'(\beta^G) < 0$, $\eta'(E[\tau_{t+s}]) < 0$ and $\eta'(s) > 0$. Thus, transmission increases in the global price level and decreases in the storage discount factor β^G and in expected transaction costs $E[\tau_{t+s}]$. Transmission increases, however, in the distance *s* to the next trade period: the longer the period of no trade takes, the stronger domestic prices respond to global prices (if storage domestic and global stocks are strictly positive during that period).

Table 1: Domestic prices and price transmission for different trade and storage regimes

Trade T_t	**Domestic Storage**	**Global Storage**	**Domestic Price p_t^D**	**Transmission Elasticity η**
yes	yes/no	yes/no	$p_t^G + \tau_t$	$\frac{p_t^G}{p_t^G + \tau_t}$
none, but expected	yes	yes	$\gamma^s p_t^G + [\beta^D]^s E[\tau_{t+s}]$	$\frac{p_t^G}{p_t^G + [\beta^G]^s E[\tau_{t+s}]}$
none, but expected	yes	no	$[\beta^D]^s E_t[p_{t+s}^G + \tau_{t+s}]$	For p_t^G: 0 For $E_t[p_{t+s}^G]$: $\frac{E_t[p_{t+s}^G]}{E_t[p_{t+s}^G + \tau_{t+s}]}$
none, but expected	no	yes/no	$D(Q_t^D, Y_t^D)$	0
none and not expected	yes	yes/no	$\beta^s E_t\left[D(Q_{t+s}^D, Y_{t+s}^D)\right]$	0
none and not expected	no	yes/no	$D(Q_t^D, Y_t^D)$	0

Source: Own elaboration.

[4] For *s=0*, the transmission elasticity collapses to the standard form (direct transmission in case of trade) $\eta = p_t^G/(p_t^G + \tau_t)$. As argued above, any ad-valorem transaction costs cancel out in the price transmission.

Table 1 gives an overview about the different possible trade and storage regimes and how they determine domestic prices and price transmission. In case of trade or in case of expected (future) trade and positive domestic and global stocks, there is always a positive price transmission from global to domestic markets. However, if global stocks are zero[5] – i.e. if global prices are not in an intertemporal equilibrium – current global prices do not affect current domestic prices. Nevertheless, current domestic prices are in equilibrium with *expected* global prices (which might, in turn, be a function of current global prices). Only in the remaining cases when all stocks are zero or when there will never be trade, domestic prices are completely de-coupled from global prices. In these cases, domestic prices are solely determined by domestic supply and demand conditions and price transmission is zero.

The theoretical analysis reveals two further interesting insights: For each trade regime, the transmission elasticity η is not affected by ad-valorem transaction costs (which include ad-valorem taxes and tariffs) and it is further independent of the traded amount. In other words, the transmission elasticity will be the same for a country with small and large imports as long as the (unit) transaction costs are the same. Finally, the formal analysis emphasizes the role of storage for price transmission. Traditionally, storage is seen as a buffer against supply shocks which reduces price fluctuations. As (private) storage, however, links current and future prices via expectations, it links domestic prices to global prices even if no trade occurs. Hence, storage could make a country more vulnerable against international price shocks because domestic prices are linked to international prices additionally through expectations.

While trade and storage link domestic prices to international prices of the same commodity, substitution effects might also link non-traded commodities to international prices if they are substitutes for traded commodities. The magnitude of substitution effects is expressed in the cross-price elasticity of demand, denoting the percentage change of a commodity price in relation to a percentage change of the price of the substitute. Hence, we would also expect price transmission to non-traded local products if they are substitutes for traded commodities. This is in particular the case for staples or for different edible oils.

[5] Zero stocks refer here to the theoretical model. In real-world settings stocks become rarely zero because a certain amount of grains will be always stored for operational purposes. This 'operational stock', however, is not part of the intertemporal arbitrage dynamics as it is used to ensure deliveries and does not respond to (expected) prices.

4 Empirical Model

As we are interested in the transmission of global shocks to domestic prices, any empirical analysis should consider intra-annual prices. Many of the variables that determine price transmission like grain stocks and trade are, however, only observable on an annual basis and suffer additionally from substantial measurement errors and data quality problems.[6] While there are models that allow combining data of different frequencies (e.g. GARCH-MIDAS for analyzing volatility, see Engle *et al.* (2013)) their estimation requires typically a large sample size. Because most of our price series start after the year 2000, we use a pure time-series approach to quantify country and crop specific 'average' transmission elasticities instead of estimating the underlying fundamental model parameters like the transaction costs, trade flows and storage levels.

Time series models are often confronted with the problem of non-stationary data series which generates biased estimates and high R^2 due to spurious regression of explanatory variables with trends or leads to overestimated t-values in case of autocorrelation. The typical approach to deal with non-stationary time series is to difference the data until it becomes stationary. If the time series are additionally co-integrated (i.e. there exists a linear combination of the series that is integrated of order one), it is possible to estimate the long-run relationship between trended variables within an error correction model (ECM) (Engle and Granger, 1987). If the time series are integrated of order one but not co-integrated, one can analyze the first-differenced, stationary time series within an Autoregressive Distributive Lag Model (ADL). If the time series are stationary, the ECM can be made equivalent to an ADL (De Boef and Keele, 2008).

An ECM would be the favorable model to test for market integration (i.e. co-integration of domestic and international price series). Transmission of short-term shocks of international prices to domestic prices, which is the focus of this paper, however, does not require co-integrated time series. Restricting to co-integrated time series could exclude countries with

[6] Stocks data is, for example, lacking for many countries. Published stock data (e.g. on the USDA-PSD database) is for many developing countries based on rough estimates and balance-sheet calculations rather than original survey data.

significant transmission of shocks.[7] Using an ADL for this set of countries would be one option. As the estimated short-run transmission elasticities of the ADL are not directly comparable to the ECM which controls for error correction, we prefer to use the same econometric model for all countries and series. Hence, we use an ADL with stationary first-differenced logarithmic prices which is suitable for all countries and price series.[8] Our basic model estimates the relative change of the domestic food price index as follows:

$$\Delta p_{it}^{d} = \sum_{j=1}^{l} \alpha_i^{dw}\, \Delta p_{it-j}^{d} + \sum_{j=1}^{k} \beta_{ij}^{dw} \Delta p_{t-j}^{w} + \sum_{j=1}^{k} \gamma_{ij}^{dw} \Delta e_{it-j} + \sum_{j=1}^{k} \zeta_{ij}^{dw} \Delta p_{t-j}^{oil} + \delta_{im}^{dw} + c_i^{dw} + \varepsilon i,tdw \quad (5)$$

where $\Delta x_t = x_t - x_{t-1}$ is the difference operator, $p_{i,t}^{d}$ denotes the domestic reference price *d* (or price index) in country *i* (all prices in logs) at time t, p_{t-j}^{w} is a world market reference price (or price index), $e_{i,t-j}$ the exchange rate (in US dollar) of country *i*, p_t^{oil} is the oil price, $\delta_{i,m}$ a monthly country-specific dummy to account for seasonality, and c_i^{dw} is a (country and commodity specific) constant. We chose the lag structure l=3 and k=3 in our base model but we explore different lag structures (including optimal lags using information criteria) as a robustness check. Although oil prices are neglected in most other studies, we consider them to be important as they influence domestic production and transportation costs as well as import costs (Minot, 2010).

Controlling for seasonality (Helmberger and Chavas, 1996) and oil prices may consider important determinants of food and grain prices in particular countries; it might, however, also weaken the reliability of the model due to decreased degrees of freedom for countries in which seasonality or oil prices are irrelevant. We therefore use the Akaike information criterion of the full model, a model without oil prices, a model without seasonality and a model without both, oil prices and seasonality, to select for each country and commodity the appropriate model specification automatically.

[7] Additionally, testing for the existence of a unit root process, a necessary condition for the ECM, is problematic due to the low performance of unit root tests. Hence, the use of the ADL avoids the risk of using a mis-specified ECM.

[8] Stationarity for all domestic and international price series was tested using the Augmented Dickey-Fuller test. While only few of the original series are stationary, all first-differenced series are stationary with a test statistic below the 1% critical value. Results are available upon request.

We run the regression in Eq. (5) separately for each country i, each international reference price p_t^w and each considered domestic food price p_t^d. With the estimated coefficients, we calculate the short-run transmission $\beta_i^{dw} = \sum_{j=1}^{k} \beta_{ij}^{dw}$ and the pass-through θ (i.e. the equilibrium effect on the domestic food price index of a marginal world price change) of international price *w* to domestic price *d* in country *i* as:

$$\theta_i^{dw} = \frac{\sum_{j=1}^{k} \beta_{ij}^{dw}}{1 - \sum_{j=1}^{l} \alpha_{ij}^{dw}}$$

where $\beta_i^{dw} = \sum_{j=1}^{k} \beta_{ij}^{dw}$ and $\alpha_i^{dw} = \sum_{j=1}^{l} \alpha_{ij}^{dw}$ are set to zero if they are not significant at the 5% level (F-test with Newey-West estimated standard errors).[9] While β_i^{dw} gives the direct (short-term) price transmission within one to three months, the auto-regressive term α_i^{dw} further amplifies price changes in subsequent periods. The total effect is therefore given by the pass-through θ_i^{dw}. As we estimate β_i^{dw} and θ_i^{dw} separately for each country and international commodity price (index), we obtain for each domestic food price index *d* a matrix of transmission elasticities and pass-throughs.

5 Data

This study differs from others in using an extensive dataset of international commodity prices and price indices, ranging from spot prices at important export destinations to prices of relevant futures contracts.

Table 3 in the Appendix lists the prices that are used as international reference prices and price indices. The main sources are FAO and FAO GIEWS for the international food prices and price indices, World Bank (2013b) for important international spot prices and Bloomberg for futures prices. We also calculate indices over futures prices in order to better capture price dynamics on commodity exchanges. For all futures prices, a time series consisting of the respective active

[9] Significance levels of 10% and 1% were also employed to check robustness (see below). The Newey-West estimator corrects for heteroskedasticity and autocorrelation. We use a lag-length of 6 months. The standard OLS procedure gives similar results (see below).

contract has been used. All price data is monthly (for daily price series like futures prices monthly averages are calculated).

Regarding the domestic prices, the food price indices (FPI) from the national consumer price indices (CPI) serve as reference database. This data are available from the LABORSTA database for 200 countries of the world in a monthly or quarterly frequency (ILO, 2013). We drop those countries which only report quarterly food price indices and consider the years 2000-2012.[10] While the LABORSTA database has the advantage of high country coverage, the calculation of the food price indices is not transparent for many countries. In particular, CPI's may suffer from urban bias as price collection in urban area is less expensive than in remote rural areas. Additionally, the weights in the CPI might reflect consumption and spending of the urban lower middle class rather than the expenditure of very poor households that spent up to 70 percent of their expenditures on staple food (James, 2008). For example, dramatic changes in staple prices that affect the real income of poor households might only lead to small changes in the domestic food price index which consists of processed foods as well as luxury food and beverages.

Because FPI data might be inadequate to monitor the costs of food for poor people, we develop an alternative staple grain price index which consists of the retail prices of wheat, maize, rice, sorghum and millet. We used several sources to compile this retail price database and calculate the national average price in US$ over different markets for each of the commodity price. We use prices in US$ to avoid the problem of strong inflationary shocks that are difficult to control for but provide robustness checks for prices in nominal and CPI-deflated local currencies. We combine the different commodity prices to a price index according to their share on domestic per capita food supply (taken from FAOSTAT (2013)):

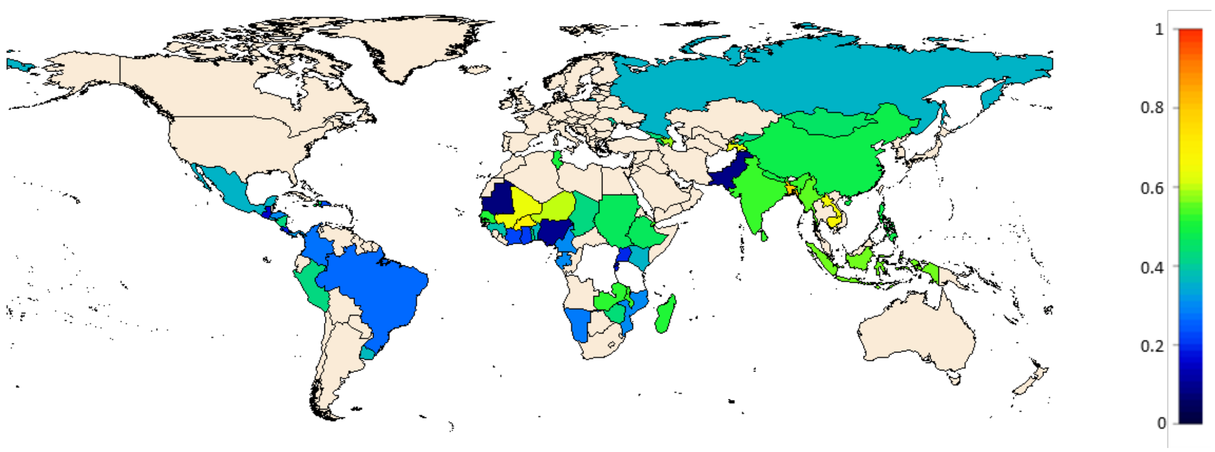
$$p_{it}^{GPI} = \sum_{j} \alpha_{ij} p_{itj}$$

Where $\alpha_{ij} = C_{ij}/C_j$ is the share of the j-th crop on the total consumption of the considered grains in country i in kg over the period 2000-2009 and p_{itj} the corresponding crop price at

[10] These countries are (20 in total): AIA, ASM, AUS, BLZ, BTN, COK, CYM, FRO, GUM, JEY, KIR, MHL, MNP, NFK, NIU, PNG, SHN, SPM, TUV, VUT

month *t* in US$ per kg. We either use the national average price if provided by one of the databases in Table 2 or calculate an (unweighted) national average price from all markets price data was available (again, using the sources in Table 2). Our self-constructed grain price index accounts for roughly 50 percent of the average national calorie consumption in many countries (see Figure 2). As the diet of poor people consists of a higher share on staples, our grain price index is likely to cover more than the national average number for poor people which increases its relevancy.

Figure 2. Share of domestic caloric food supply of the alternative grain price index (GPI) on total domestic caloric food supply



Source: Own elaboration.

One drawback of the grain price index is the limited data availability. As visible in Figure 2, retail grain prices were not available for a large number of countries. Yet, as will be discussed later, the considered countries are home to more than 90 percent of the global poor that live with an income below 1.25$ per day. Thus, the coverage with respect to poor people is much better than the 'geographical' coverage revealed in Figure 2. Another drawback of the grain price index is its likely irrelevance for those countries where other staples than our considered grains are relevant for the food diet (for example roots and tubers in Uganda). Because of the advantages and disadvantages of both, food price indices and grain price indices, we consider both in our analysis. Table 2 summarizes the characteristics and data sources for the domestic price indices.

Table 2. Domestic food price indices

d	Variable	Description	Source
FPI	Food price index (FPI)	National food price index (nominal); 2000-2012	ILO (2013)
GPI	Domestic grain price index (GPI)	Index of the national average retail prices (nominal US$) of five staple grains for 2000-2012: wheat, maize, rice, sorghum and millet; weighted according to domestic per capita food supply for 2000-2009	Own calculation; domestic per capita food supply from FAO; retail prices from FEWS.NET, FAO GIEWS, WFP Price Monitor and national sources

Source: Own elaboration.

Exchange rates were used from the IMF database. For the oil price, we consider the 'average oil price' of WTI, Brent and Dubai prices quoted at World Bank Commodities Price Database.

6 Results

This section presents and discusses the calculated transmission elasticities. For policy makers as well as for early warning information systems it might be relevant to know: First, whether a country's food prices are linked to at least one international commodity price. In the second step, one can access the database on transmission elasticities to look which particular commodity prices are transmitted to local prices of that particular country. We therefore calculate a country-specific transmission *vulnerability indicator* V_i^d as the maximum transmission over the pass-throughs of different commodities from the set Ω:

$$V_i^d = \max_{w \in \Omega} \{\theta_i^{dw}\} \quad (5)$$

If this indicator is zero, domestic food markets are with high certainty not vulnerable to global price shocks.[11] If the indicator is high, there is high transmission for at least one international commodity price (or price index) which implies a general vulnerability of the country to global

[11] However, they might still be co-integrated with world markets (through rather slow adjustment process) as we do not test for co-integration.

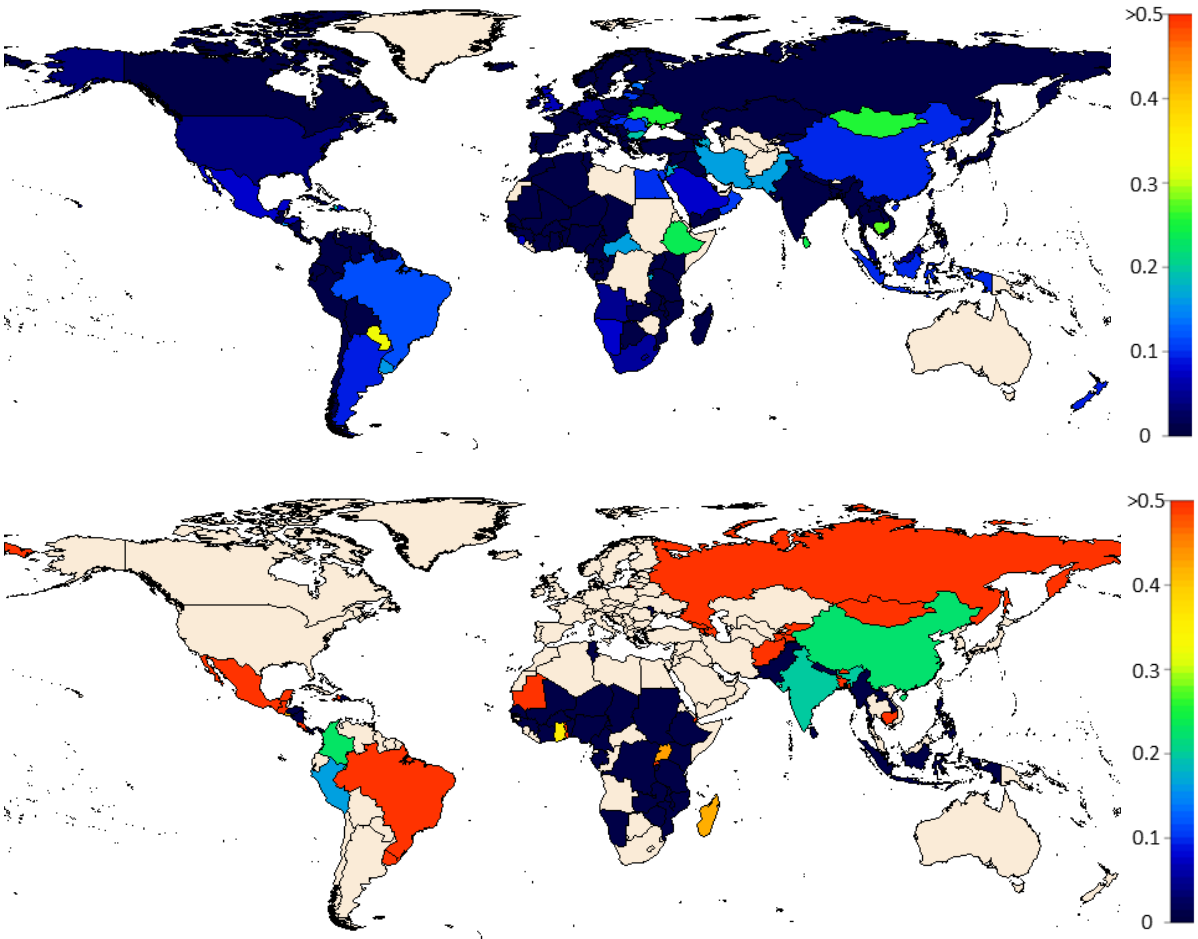
market price changes. As we will see, the vulnerability indicator provides an important benchmark against single international prices or price indices like the FAO Food Price Index. We further calculate vulnerability indicators for sub-sets Ω of commodities, for example, we calculate V_i^d as maximum pass-through over all international rice prices.

6.1 Transmission from the FAO Food Price Index

We first consider the transmission from the FAO Food Price Index – an international reference price index which is often used as indicator for global food market dynamics. We run regressions for the transmission to domestic food prices as well as to domestic grain prices. The magnitude of the aggregate transmission elasticity β (if significant at the 5% level) is depicted in Figure 3 for both, the domestic food price index (upper panel) as well as the domestic grain price index (lower panel). The maps indicate that there is no significant transmission for several developing countries in Asia, Latin America and Africa. If there is statistically significant transmission, it tends to be particularly high. These findings are consistent with other studies mentioned above but provide a more comprehensive country coverage.

The global transmission map on the domestic food price index where we have data for almost all countries of the world reveals another interesting finding: Several developed countries (North America, Europe) show a statistically significant but low price transmission while transmission to developing countries is either insignificant (i.e. zero) or relatively high. One explanation for this finding is that the food basket in developed countries consists of many processed food items where the commodity costs have only a very low share. Thus, a price increase in the raw commodity translates only into a very small price increase in the final product. This explains why the US has a very low price transmission – although several of the international reference prices used are quoted from US markets. The high variance of transmission for developing countries is based on the fact that some countries are simply not integrated into the world market due to high transaction costs. If countries are integrated, price transmission is relatively high because the raw commodity costs are a major part of the price of many food items.

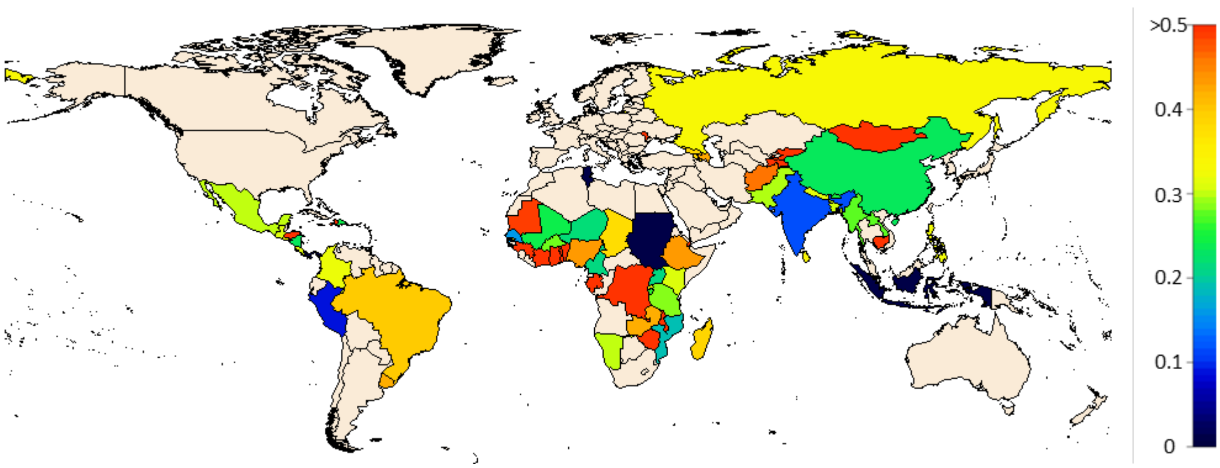
Figure 3. Transmission from the FAO Food Price Index to the Domestic Food Prices (FPI and GPI)



Note: *Top panel*: Transmission from the FAO Food Price Index to the domestic food price index; *bottom panel*: Transmission from the FAO Food Price Index to the domestic grain price index.

The FAO Food Price Index is a much aggregated price index. It uses weights according to the export share on the global market of the considered commodities. While this gives an appropriate average price index for the globally traded commodities the trade pattern for particular countries might differ enormously. For example, individual countries might predominantly import rice although the rice price has a very low weight in the FAO Food Price Index. When adding further international price indices and concentrating on the vulnerability indicator (maximum transmission) regarding all grain prices in our database, we get a different map where many Asian, African and Latin American countries experience significant and high price transmission (Figure 4). For example, some of the West African countries show high price transmission to the domestic grain price index which is primarily driven by international rice prices as these countries have high rice imports. Note that even a low transmission elasticity of 20% might have remarkable implications as doubling of commodity prices (as was experienced for wheat in 2007/2008, for example) increases the costs of the *entire food or staple commodity basket* by 20 percent. This is an important difference to other studies when comparing the results: transmission elasticities for one single commodity do not reveal how important the considered commodity is for the population. Using a price index, in contrast, weights the price transmission with the relevance of the commodity in the diet and incorporates additionally potential substitution effects.

Figure 4. Transmission to the Domestic Grain Price Index - Vulnerability Indicator over International Grain Prices.



Note. Maximum transmission to the domestic grain price index using all international grain prices in Table 3.

The use of the vulnerability indicator emphasizes that considering the FAO Food Price Index exclusively might seriously bias the assessment of price transmission downwards. Thus, it is important to consider a larger set of reference prices and price indices than relying on the FAO Food Price Index only which is, however, a pragmatic alternative when only one single international price (index) can be used.

6.2 Vulnerability Mapping: How Many Poor People Are Affected by Global Price Changes?

For an impact assessment of global price changes it is important to know how many poor people live in countries with high price transmission. Price changes have often heterogeneous impacts on the welfare of households, depending on their production structure and market access (von Braun *et al.*, 2013). High agricultural commodity prices can increase the income of poor rural households who produce cash crops (Tefera *et al.*, 2013). Nevertheless, such beneficial impacts are often realized in the medium and long-term when households adjust their production to high-value crops. However, existing empirical analyses conclude that sudden price spikes do not only make poor consumers and landless worse-off but also farmers that buy many food items as they cannot quickly adjust their production in the short-run (Aksoy and Isik-Dikmelik, 2008; Anríquez *et al.*, 2013).

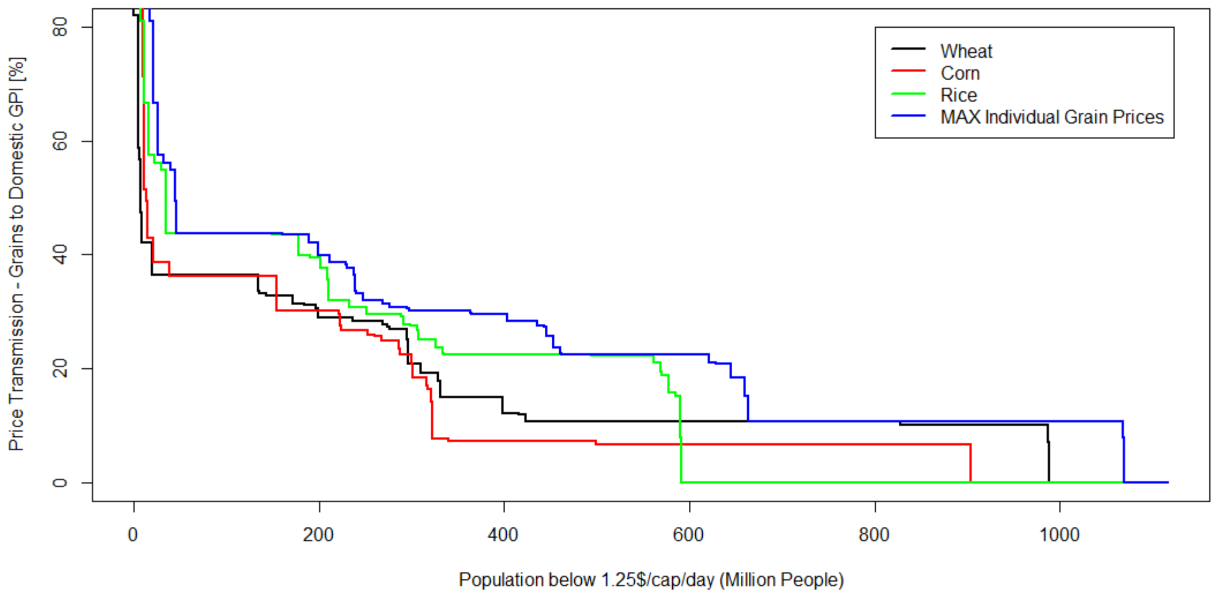
To assess how strongly poor people are exposed to global price changes, we proceed as follows: We sort the transmission elasticities β of the countries – for example from the Chicago corn price or from the vulnerability indicator that contains the maximum transmission over grain prices – in descending order. Next we calculate the number of people living below the extreme poverty line of 1.25$ per day[12] using poverty share and population data from the World Bank Development Indicators (World Bank, 2013a).[13]

Figure 5 shows the transmission from different international grain prices to the domestic grain price index. We calculated the maximum transmission (vulnerability indicator) according to Eq. (5) for each of the three commodities wheat, corn and rice. Hence, the wheat line shows the maximum transmission for each country from all the available wheat price series in Table 3. We calculate the total vulnerability indicator as maximum over the commodity indicators (blue line).

[12] Using the 'moderate poverty line' of 2$/day gives qualitatively similar results. Quantitatively, however, roughly double as many people are affected.

[13] Poverty rates are not available for every year. We use therefore the most recent number and multiplied it with the 2012 number of total population.

Figure 5. Number and Extent of Poor People Potentially Affected by International Price Changes (Change of Grain Price Index)

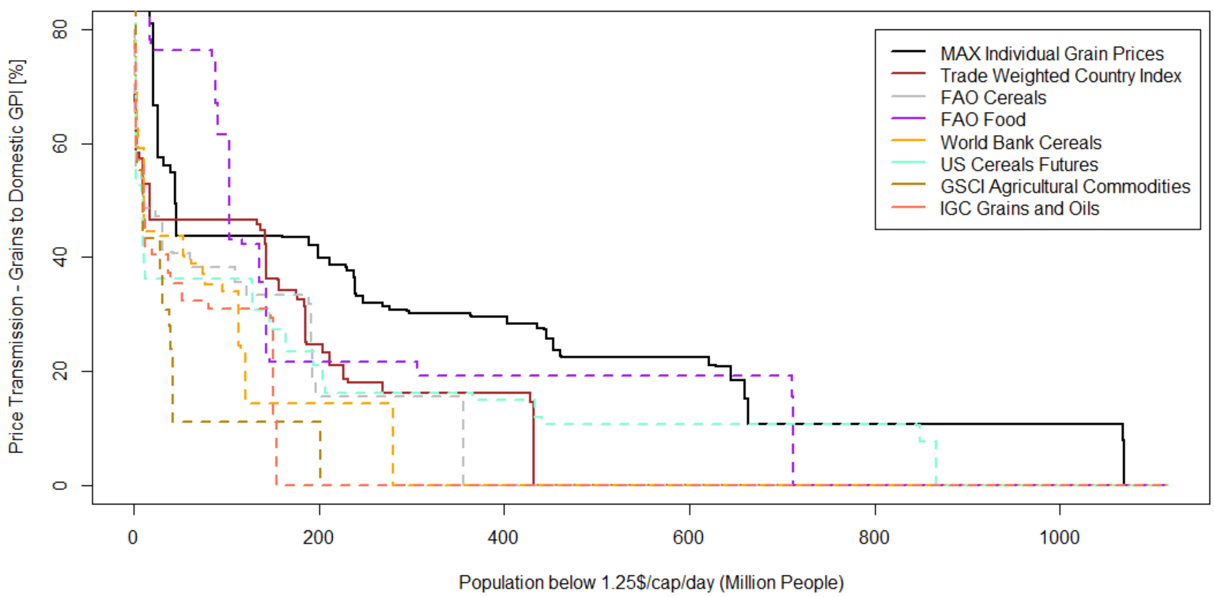


Source: Own elaboration. The figure shows the transmission elasticities over all countries in descending order mapped to the number of people below the extreme poverty line in the particular country.

Regarding the extent of transmission, Figure 5 clearly shows that rice prices are most strongly transmitted which is also highlighted by other studies (e.g. Robles 2011; Baquedano and Liefert 2014). While wheat prices experience lower transmission elasticities than rice prices for many countries, the tale is much longer due to its impact on India where one third of the globally poor live. The all-grain vulnerability indicator reveals that more than 1.06 billion poor people live in countries with significant price transmission of 10% or higher – which is 96% of the poor of our country set and 89% of the poor globally. More than 360 million poor people (one third of the poor) live in countries with transmission elasticities of 30% or higher; about 44 million poor people live in countries with transmission elasticities of 50% or higher.

We decomposed the transmission further into the individual price series (see Appendix, Figure 9 to Figure 12) to identify the most relevant international reference price for each of the commodities. For wheat, prices of the futures contracts at the Chicago Board of Trade (CBoT) are the most relevant ones, in particular regarding the number of people affected. Transmission elasticities from CBoT prices are, however, topped by transmission rates from Canadian wheat and Argentinian spot prices for particular countries (e.g. Nigeria, Ethiopia or Kenia). For maize, US spot and futures prices are transmitted at rates ranging from 15 to 50% for 150 million poor people. Yellow and White Maize prices at the South African futures exchange SAFEX are strongly transmitted to Malawi at rates higher than 70 percent. Regarding rice, there is no clear reference price emerging. IGC rice prices, Pakistani and Thai prices transmit to different extent to different countries, with Nigeria experiencing high transmission, in particular from Thai prices and the IGC price index.

Figure 6. Number and Extent of Poor People Potentially Affected by Changes of International Price Indices



Source: Own elaboration.

Comparing the transmission indicated by the all-grain vulnerability indicator with several other price indices emphasizes that each individual price index alone would underestimate the size of the affected population. The FAO Food Price Index as a popular international reference price suggests, for example, that 700 million poor are affected by global price shocks (due to its significant transmission to India and China); the FAO cereals price suggests 350 million affected people – far below the numbers from the all-grain vulnerability indicator. The FAO Food Price

Index shows a higher transmission elasticity than most indices that are based on grain prices only which is basically due to a lower variability of the FAO Food Price Index.[14]

Figure 6 further illustrates that about 850 million poor people might be affected by price changes of US cereals futures contracts (140 million with transmission rates of 30 percent or higher) which is in particular relevant for the debate on speculation and financialization (Tadesse *et al.*, 2013; von Braun *et al.*, 2013). Transmission elasticities from commodity prices and price indices for countries with at least 1 million people below the poverty line are listed in Table 4 in the Appendix.

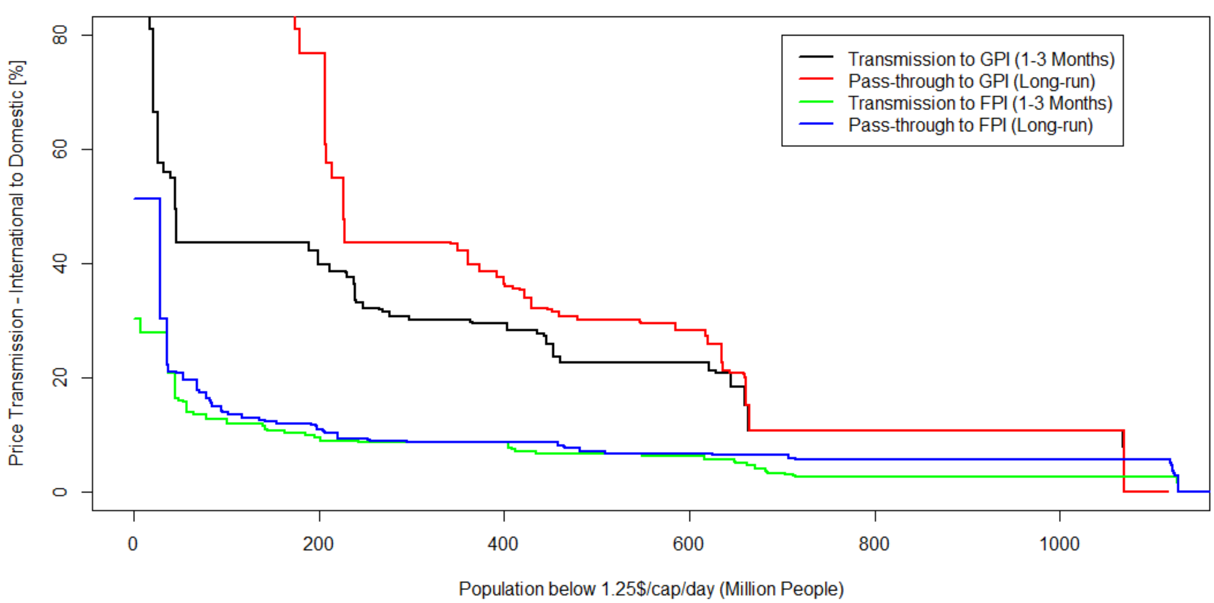
The calculations in in Figure 5 and Figure 6 require an important qualification as they represent a likely upper bound on affected people. Precisely, they show the number of poor people living in countries with a specific price transmission. Not all poor people in a country with positive price transmission experience international price changes. In developing countries, in particular Africa, poor people in remote rural areas lack access to markets due to bad infrastructure (Barrett, 2008; Nelson, 2008). As discussed previously, food price indices from national statistical agencies could be biased to urban centers making them less relevant for the rural population in remote areas. A transmission analysis based on food price indices from national statistical agencies would overstate the number of affected poor as one would expect less price transmission from international prices to remote rural markets. The use of the grain price index with grain prices also from rural markets is an important alternative because it is constructed independently from the FPI using alternative price data. Nevertheless, the considered markets are far from complete coverage and prices for many rural areas are missing. The number of poor people in affected countries is therefore only an indication of the potentially affected people (which would be the same if domestic markets were perfectly integrated).

[14] The FAO Food Price Index contains also meat and oils which are processed food items that typically fluctuate less than commodity prices. Comparing the FAO Food Price and Cereals Price Index between 1990 and 2011, the former shows average monthly change rates of ± 0.8% while the latter changes ± 1.3% per month. We would therefore expect for an identical commodity composition a roughly 60 percent higher transmission from FAO food prices compared to cereals prices.

6.3 Pass-through and equilibrium effects

While the sum of the coefficients on international prices β gives the relative magnitude of price transmission 1-3 months after a spike, the pass-through θ considers long-run equilibrium adjustments due to the autoregressive term (see Section 4 above). Figure 7 depicts the vulnerability indicator (maximum over all international grain prices) for both, transmission and pass-through, to the domestic food price index as well as to the domestic grain price index. Consistent with Figure 3 and Figure 4, we find that transmission elasticities are considerably higher for the domestic grain price index than for the domestic food price index. The long-run equilibrium effect of international price spikes is substantially higher: For high vulnerable countries, the long-run effect is approximately double as high as the short-run effect. The discrepancy between short-run transmission and long-run pass-though is higher when domestic grain prices instead of domestic food prices are considered which is due to the more important role of the auto-regressive dynamics.

Figure 7. Comparison of Transmission and Pass-through



6.4 Robustness checks

The outcome of our econometric analysis depends not only on the chosen model specification but also on the considered significance levels. We therefore discuss the implications of different model specifications for our findings. We confine only to the vulnerability indicator regarding grain prices, in particular, with its mapping to affected poor people (as shown in Figure 5).

Significance levels

If the null-hypothesis of zero transmission cannot be rejected at the 5% level, we set the transmission to zero; otherwise, we used the point estimate for the calculation of the transmission. Changing the significance level to 10% increases the likelihood to erroneously detect transmission into a country although there is none; it reduces, however the error to wrongly conclude that there is no price transmission in case the F-test does not reject the null-hypothesis of zero transmission. We therefore employed different significance levels of 10% and 1% to check the sensitivity of our results. As shown in the Appendix, a significance level of 10% has only marginal impacts on the extent of price transmission and the amount of poor affected (Figure 8). For a stricter significance level of 1%, the transmission relative to the poor population is lower: Many countries on the right tale (with low transmission rates) do not pass the stricter significance test. Nevertheless, transmission elasticities for 550 million poor in countries with significant transmission hardly change compared to the laxer significance levels.

CPI-deflated food prices

It is often argued that nominal price changes are less relevant because monetary inflation might change the overall price level and therefore the purchasing power of money. To study welfare impacts of price changes one would ideally deflate nominal prices with (nominal) income for consumers which is, however, hardly available.[15] Using the consumer price index (CPI) is a pragmatic alternative although CPIs do not measure the income or wage of people, but the costs of goods a representative consumer buys. For some countries (e.g. Bangladesh), food items have a share over 50% of the CPI (ILO, 2013). Thus, even without any monetary inflation

[15] For households with substantial income from selling their agricultural produce, prices of inputs need also to be considered (Dorward, 2011).

and without any increases in wages or other consumption goods an increase in food prices by 10% would increase the CPI by more than 5%. Deflating the food price change with the CPI would then result in a 'real' price change by 5% although wages and other consumer prices would remain constant. Deflating the food price index with the CPI would in such a case understate the welfare impact due to price changes.

Due to the lack of monthly wage or income data, we resort to deflate food prices by the CPI despite the known shortcomings. As our grain price index uses prices in US dollar which shows very low monthly inflation rates, we perform this robustness check only for the domestic food price analysis. As expected, transmission to CPI-deflated food price indices is lower than to nominal food prices (Figure 8). The transmission-population curves are similar to our standard model, although slightly lower to the right tale (in particular, for India which experiences high inflation). Using nominal prices in the local currency give also similar results to our standard model. The robustness of our findings regarding the choice of the currency and deflator is probably based on the use of first-differences of log prices which cancel out inflation as well as the use of heteroscedacity-corrected standard errors by the Newey-West method.

OLS vs. Newey-West

To check the robustness of the Newey-West approach with time lags of six months, we also include regressions based on standard OLS where homoscedasticity is assumed for calculating standard errors and, thus, significance levels. OLS allows for a much faster calculation of the standard errors which becomes important when applying to many country and commodity time series. As indicated in Figure 8, OLS gives similar results although transmission rates are slightly lower as high transmission elasticities for some commodities do not pass the t-test at the 5%-level anymore.

7 Conclusions

The aim of this paper is to better understand the transmission of shocks in international prices to domestic food prices. Our analytical model emphasizes that international price changes can be transmitted through intertemporal arbitrage of storage even if no trade takes place. Our empirical analysis suggests that focusing only on the FAO Food or Cereal Price Indices might understate the vulnerability of the poor to international price changes. Likewise, food price indices from national statistics might be biased to (on average wealthier) urban consumers that buy and consume relatively more processed staples and luxuries. To avoid these shortcomings, we use a comprehensive database on international reference prices and construct a domestic grain price index based on retail prices in developing countries and the share of the considered commodities on consumption. Our price database allows for almost universal country coverage, in particular, with respect to countries where poor people live. We are therefore for the first time able to estimate how many poor people live in countries where international price changes are transmitted to domestic prices.

Our empirical analysis illustrates that the vast majority of the poor (over 90 percent) live in countries where food prices are linked more or less strongly to international prices *in the short term*, i.e. within one to three months. For 360 million poor people, international prices transmit to their country at rates of 30 percent or higher. The empirical analysis considered seasonality and oil prices (endogenous model selection). The findings are robust for different significance levels and price deflators.

Because of our lag structure of three months, we expect that international price shocks will translate to domestic price shocks rather quickly. Existing research on the impact of price changes on welfare of poor consumers pays attention to the differentiated and heterogeneous effects of price changes, depending on the production and consumption structure. While higher prices can benefit net-sellers of the affected crops, they make poor consumers, net-buyer farmers and rural landless worse-off in the short-term. Several quantitative estimates conclude that the negative effects overweigh the positive effects, for example, with respect to the number of people falling below the poverty line – at least in the short term when production is not able to respond flexibly (Ivanic and Martin, 2008; Tiwari and Zaman, 2010; de Hoyos and Medvedev, 2011; Anríquez *et al.*, 2013). There is also a concern that price increases affect poor consumers more than the effect of a symmetric price decrease on producers of food: While the former can run into serious problems to afford sufficient food, the latter may have remarkable income reductions but still enough (self-grown) food to eat (Kalkuhl *et al.*, 2013).

Although our analysis focuses on the transmission of price levels rather than price risk or volatility, one can presume that high international volatility (measured in the fluctuations of *monthly* prices) will also increase domestic food price volatility.[16] While the welfare impacts of price changes are ambiguous, volatility may have negative effects through increasing the production risks for farmers and, thus, undermining long-term food supply (Haile and Kalkuhl, 2013; Haile *et al.*, 2013).

The transmission analysis and the estimated elasticities could be used in early warning systems to detect vulnerable countries in times of high international price swings. It could further be extended to explain the different degrees of price transmission by other explanatory variables like transportation costs, trade, GDP or grains stocks.

[16] An appropriate econometric analysis would investigate directly volatility transmission, e.g. with a MGARCH-BEKK/DCC (see Hernandez *et al.*, 2013 for an application to international commodity exchanges).

References

Aksoy, A., Isik-Dikmelik, A., 2008. Are Low Food Prices Pro-Poor? Net Food Buyers and Sellers in Low-Income Countries. Net Food Buyers and Sellers in Low-Income Countries (June 1, 2008). World Bank Policy Research Working Paper Series, Vol.

Anríquez, G., Daidone, S., Mane, E., 2013. Rising food prices and undernourishment: A cross-country inquiry. Food Policy 38, 190-202.

Baquedano, F.G., Liefert, W.M., 2014. Market integration and price transmission in consumer markets of developing countries. Food Policy 44, 103-114.

Barrett, C.B., 2008. Smallholder market participation: Concepts and evidence from eastern and southern Africa. Food Policy 33, 299-317.

Cachia, F., 2014. Regional Food Price Inflation Transmission., ESS Working Paper No. 14-01. FAO, Rome.

De Boef, S., Keele, L., 2008. Taking time seriously. American Journal of Political Science 52, 184-200.

de Hoyos, R.E., Medvedev, D., 2011. Poverty Effects of Higher Food Prices: A Global Perspective. Review of Development Economics 15, 387-402.

Dorward, A., 2011. Getting real about food prices. Development Policy Review 29, 647-664.

Engle, R.F., Ghysels, E., Sohn, B., 2013. Stock market volatility and macroeconomic fundamentals. Review of Economics and Statistics 95, 776-797.

Engle, R.F., Granger, C.W., 1987. Co-integration and error correction: representation, estimation, and testing. Econometrica: journal of the Econometric Society, 251-276.

FAO, 2013. The State of Food Insecurity in the World. Rome.

FAOSTAT, 2013. Database.

Götz, L., Glauben, T., Brümmer, B., 2013. Wheat export restrictions and domestic market effects in Russia and Ukraine during the food crisis. Food Policy 38, 214-226.

Greb, F., Jamora, N., Mengel, C., von Cramon-Taubadel, S., Würriehausen, N., 2012. Price transmission from international to domestic markets.

Haile, M.G., Kalkuhl, M., 2013. Agricultural supply response to international food prices and price volatility: a crosscountry panel analysis. 2013 Annual Meeting, August 4-6, 2013, Washington, DC. Agricultural and Applied Economics Association.

Haile, M.G., Kalkuhl, M., von Braun, J., 2013. Short-term global crop acreage response to prices and implications of volatility. ZEF Discussion Paper 175.

Helmberger, P.G., Chavas, J.-P., 1996. The economics of agricultural prices. Prentice-Hall Inc.

Hernandez, M.A., Ibarra, R., Trupkin, D.R., 2013. How far do shocks move across borders? Examining volatility transmission in major agricultural futures markets. European Review of Agricultural Economics, forthcoming.

Ianchovichina, E., Loening, J., Wood, C., 2012. How vulnerable are Arab countries to global food price shocks? World Bank Policy Research Working Paper.

ILO, 2013. LABORSTA Labour Statistics Database.

Ivanic, M., Martin, W., 2008. Implications of higher global food prices for poverty in low-income countries1. Agricultural Economics 39, 405-416.

James, W.E., 2008. Food Prices and Inflation in Developing Asia: Is Poverty Reduction Coming to an End? Asian Development Bank.

Kalkuhl, M., Kornher, L., Kozicka, M., Boulanger, P., Torero, M., 2013. Conceptual framework on price volatility and its impact on food and nutrition security in the short term. FoodSecure Working Paper no. 15.

Kornher, L., Kalkuhl, M., 2013. Food price volatility in developing countries and its determinants. Quarterly Journal of International Agriculture 52, 277-308.

Minot, N., 2010. Transmission of world food price changes to markets in Sub-Saharan Africa.

Nelson, A., 2008. Travel time to major cities: A global map of Accessibility. Ispra: European Commission.

Ravallion, M., 1986. Testing market integration. American Journal of Agricultural Economics 68, 102-109.

Robles, M., 2011. Price transmission from international agricultural commodity markets to domestic food prices: Case Studies in Asia and Latin America. . IFPRI, Washington, DC.

Samuelson, P.A., 1952. Spatial price equilibrium and linear programming. The American Economic Review 42, 283-303.

Tadesse, G., Algieri, B., Kalkuhl, M., von Braun, J., 2013. Drivers and triggers of international food price spikes and volatility. Food Policy forthcoming.

Tefera, N., Demeke, M., Rashid, S., Kayitakire, F., 2013. Do rural farming households benefit from high food prices? Food and Nutrition Security Policy Implications in 18 Villages.

Tiwari, S., Zaman, H., 2010. The impact of economic shocks on global undernourishment. World Bank Policy Research Working Paper Series, Vol.

von Braun, J., Algieri, B., Kalkuhl, M., 2013. World Food System Disruptions in the Early 2000s: Causes, Impacts and Cures. World Food Policy 1.

World Bank, 2013a. Development Indicators.

World Bank, 2013b. Global Economic Monitor (GEM) Commodities (Pink Sheet). World Bank Data

Wright, B.D., Williams, J.C., 1991. Storage and commodity markets. Cambridge, UK: Cambridge University.

Appendix

International Reference Prices and Price Indices

Table 3. Considered international reference prices and price indices

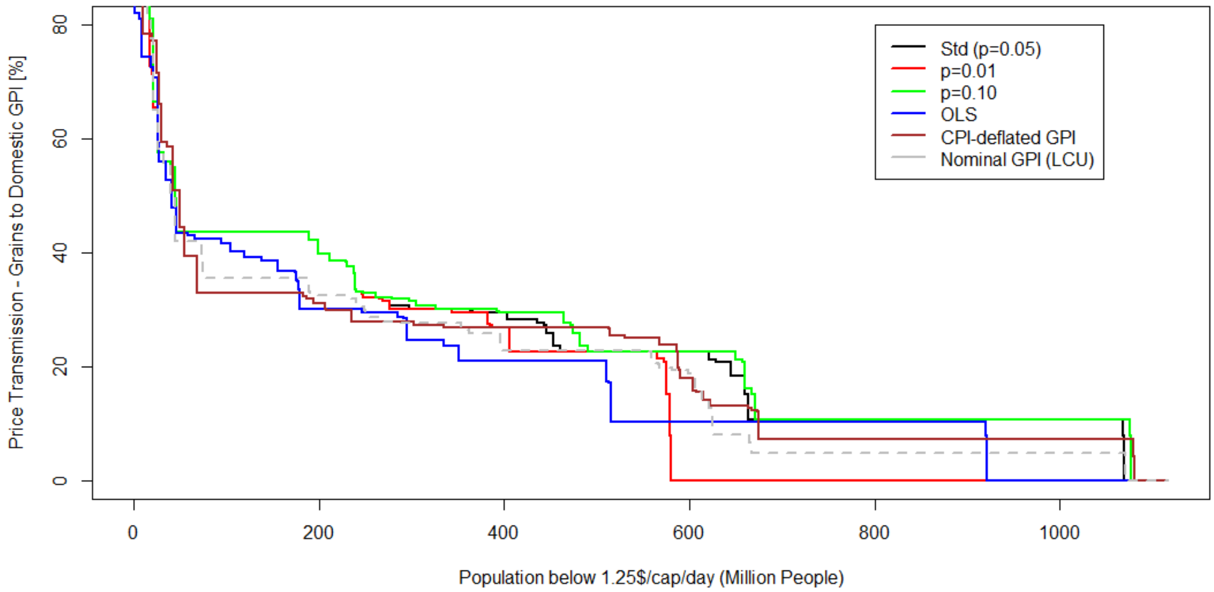
w	Variable	Description	Source
1	FAO food price index	Consists of 55 commodity quotations considered as representing the international prices of food commodities; weighted by export share	FAO
2	FAO cereals price index	Consists of wheat, maize and rice prices; weighted by export share	FAO
3	FAO oil/fat price index	Consists of 12 different oils (including animal and fish oils); weighted by export share	FAO
4	FAO sugars price index	Index form of the International Sugar Agreement prices with 2002-2004 as base	FAO
5	FAO meat price index	Consists of poultry, bovine meat, pig meat and ovine meat products; weighted by export share	FAO
6	FAO diary price index	Consists of butter, skimmed milk powder, whole milk powder, cheese and casein prices; weighted by export share	FAO
7	WB grains price index	Includes barley, maize, rice and wheat	World Bank
8	WB fats and oils price index	Includes coconut oil, groundnut oil, palm oil, soybeans, soybean oil and soybean meal.	World Bank
9	Wheat (HRW) US	No. 1, hard red winter, ordinary protein, export price delivered at the US Gulf port for prompt or 30 days shipment	World Bank
10	Wheat (SRW) US	No. 2, soft red winter, export price delivered at the US Gulf port for prompt or 30 days shipment	World Bank
11	Wheat CAN	Wheat (Canada), no. 1, Western Red Spring (CWRS), in store, St. Lawrence, export price	World Bank
12	Wheat AUS	Australian soft white, Australia, f.o.b. Australia Eastern States Standard White Wheat FOB Spot (for 10/2007-09/2008 where USDA/IGC series has missing entries)	USDA/IGC Bloomberg
13	Barley	Barley (Canada), feed, Western No. 1, Winnipeg Commodity Exchange, spot, wholesale farmers' pric	World Bank
14	Sorghum US	Sorghum (US), no. 2 milo yellow, f.o.b. Gulf ports	World Bank
15	Corn US	Maize (US), no. 2, yellow, f.o.b. US Gulf ports	World Bank
16	Soybeans	Soybeans (US), c.i.f. Rotterdam	World Bank
17	Soybean oil	Soybean oil (Any origin), crude, f.o.b. ex-mill Netherlands	World Bank
18	Soybean meal	Soybean meal (any origin), Argentine 45/46% extraction, c.i.f. Rotterdam beginning 1990; previously US 44%	World Bank
19	Rice Thai A1	Rice (Thailand), 100% broken, A.1 Super from 2006 onwards, government standard, f.o.b. Bangkok; prior to 2006, A1 Special, a slightly lower grade than A1 Super	World Bank
20	Rice Thai 5%	Rice (Thailand), 5% broken, white rice (WR), milled, indicative price based on weekly surveys of export transactions, government standard, f.o.b. Bangkok	World Bank
21	Rice Thai 25%	Rice (Thailand), 25% broken, WR, milled indicative survey price, government standard, f.o.b. Bangkok	World Bank
22	Rice Vietnam	Vietnamese rice, 5% broken	World Bank
23	Palm oil	Palm oil (Malaysia), 5% bulk, c.i.f. N. W. Europe	World Bank
24	Groundnut oil	Groundnut oil (any origin), c.i.f. Rotterdam	World Bank
25	Coconut oil	Coconut oil (Philippines/Indonesia), bulk, c.i.f. Rotterdam	World Bank
26	Fishmeal	Fishmeal (any origin), 64-65%, c&f Bremen, estimates based on wholesale price, beginning 2004; previously c&f Hamburg	World Bank
27	Beef	Meat, beef (Australia/New Zealand), chucks and cow forequarters, frozen boneless, 85% chemical lean, c.i.f. U.S. port (East Coast), ex-dock, beginning November 2002; previously cow forequarters	World Bank

28	Chicken	Meat, chicken (US), broiler/fryer, whole birds, 2-1/2 to 3 pounds, USDA grade "A", ice-packed, Georgia Dock preliminary weighted average, wholesale	World Bank
29	Sheep	Meat, sheep (New Zealand), frozen whole carcasses Prime Medium (PM) wholesale, Smithfield, London beginning January 2006; previously Prime Light (PL)	World Bank
30	Wheat / CBT	#2 Soft Red Winter at contract price, #1 Soft Red Winter at a 3 cent premium, Chicago Board of Trade	Bloomberg
31	Corn / CBT	#2 Yellow at contract Price, #1 Yellow at a 1.5 cent/bushel premium #3 Yellow at a 1.5 cent/bushel discount, Chicago Board of Trade	Bloomberg
32	Soybeans / CBT	#2 Yellow at contract price, #1 Yellow at a 6 cent/bushel premium, #3 Yellow at a 6 cent/bushel discount, Chicago Board of Trade	Bloomberg
33	Soybean oil / CBT	Crude soybean oil meeting exchange-approved grades and standards, Chicago Board of Trade	Bloomberg
34	Soybean meal / CBT	48% Protein Soybean Meal, Chicago Board of Trade	Bloomberg
35	Rough Rice / CBT	U.S. No. 2 or better long grain rough rice with a total milling yield of not less than 65% including head rice of not less than 48%, Chicago Board of Trade	Bloomberg
36	Feeder Cattle / CME	650-849 pound steers, medium-large #1 and medium-large #1-2, Chicago Mercantile Exchange	Bloomberg
37	Live Cattle / CME	55% Choice, 45% Select, Yield Grade 3 live steers, Chicago Mercantile Exchange	Bloomberg
38	Lean Hogs / CME	Hog (barrow and gilt) carcasses, Chicago Mercantile Exchange	Bloomberg
39	Wheat / KCBT	Hard Red Winter Wheat, No. 2 at contract price; No. 1 at a 1 1/2-cent premium; Kansas City Board of Trade	Bloomberg
40	Wheat / MGEX	Hard Red Spring Wheat, No. 2 or better Northern Spring Wheat with a protein content of 13.5% or higher; Minneapolis Grain Exchange	Bloomberg
41	White Maize / SAFEX	South African Futures Exchange; starting in 08/1996	Bloomberg
42	Yellow Maize / SAFEX	South African Futures Exchange; starting in 08/1996	Bloomberg
43	Wheat / SAFEX	South African Futures Exchange; starting in 11/1997	Bloomberg
44	Soybean / SAFEX	South African Futures Exchange; starting in 04/2002	Bloomberg
45	Sunflower Seeds / SAFEX	South African Futures Exchange; starting in 02/1999	Bloomberg
46	Palm oil / MDEX	Malaysia Derivatives Exchange; starting in 03/1995	Bloomberg
47	GSCI Agriculture	Price index over active futures with the 2012 S&P GSCI weights on wheat (CBT), wheat (KCBT), corn, soybeans, lean hogs, live cattle and feeder cattle (all CBT)	Own calculation
48	Trade weighted country index	Price index over US corn, US HRW and Thai 5% spot prices according to the trade shares (imports plus exports of commodity divided by imports plus exports of all three commodities) of each country	Own calculation
49	Rice / Vietnam	Viet Nam, Rice (25% broken), Export	FAO GIEWS
50	Rice / Vietnam	Viet Nam, Rice (5% broken), Export	FAO GIEWS
51	Rice / Pakistan	Pakistan, Rice (25% broken), Export	FAO GIEWS
52	Rice / Pakistan	Pakistan, Rice (Basmati Ordinary), Export	FAO GIEWS
53	Rice / USA	USA, Rice (U.S. Long Grain 2.4%), Export	FAO GIEWS
54	Rice / USA	USA, Rice (U.S. California Medium Grain), Export	FAO GIEWS
55	Rice / Thailand	Thailand: Bangkok, Rice (25% broken), Export	FAO GIEWS
56	Rice / Thailand	Thailand: Bangkok, Rice (5% broken), Export	FAO GIEWS
57	Rice / Thailand	Thailand: Bangkok, Rice (Fragrant 100%), Export	FAO GIEWS
58	Rice / Thailand	Thailand: Bangkok, Rice (Glutinous 10%), Export	FAO GIEWS
59	Rice / Thailand	Thailand: Bangkok, Rice (Parboiled 100%), Export	FAO GIEWS
60	Rice / Thailand	Thailand: Bangkok, Rice (Thai 100% B), Export	FAO GIEWS
61	Rice / Thailand	Thailand: Bangkok, Rice (Thai A1 Super), Export	FAO GIEWS
62	Wheat / Argentina	Argentina, Wheat (Argentina, Up River, Trigo Pan), Export	FAO GIEWS
63	Maize / Argentina	Argentina, Maize (Argentina, Up River), Export	FAO GIEWS

Source: Own elaboration.

Robustness Checks for Transmission to Grain Price Index

Figure 8. Global Price Transmission to the Domestic Grain Price Index under Different Significance Levels and Model Specifications



Source: Own elaboration.

Price Transmission from Individual Grain Prices

Figure 9. Transmission from several international wheat prices to the domestic grain price index and affected people.

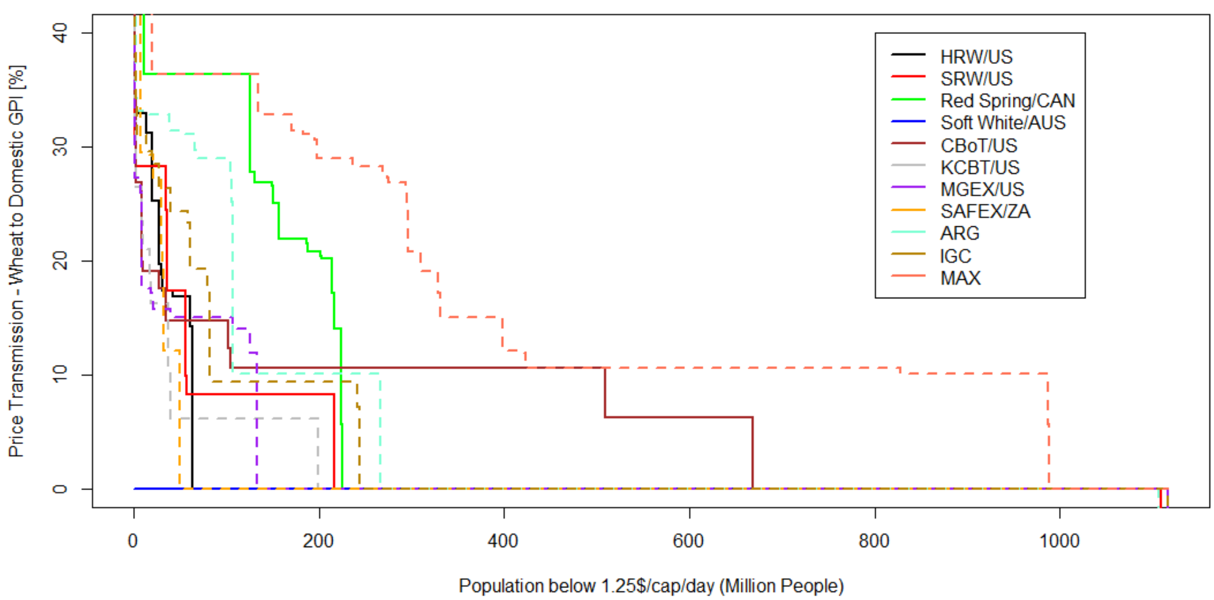


Figure 10. Transmission from several international maize prices to the domestic grain price index and affected people.

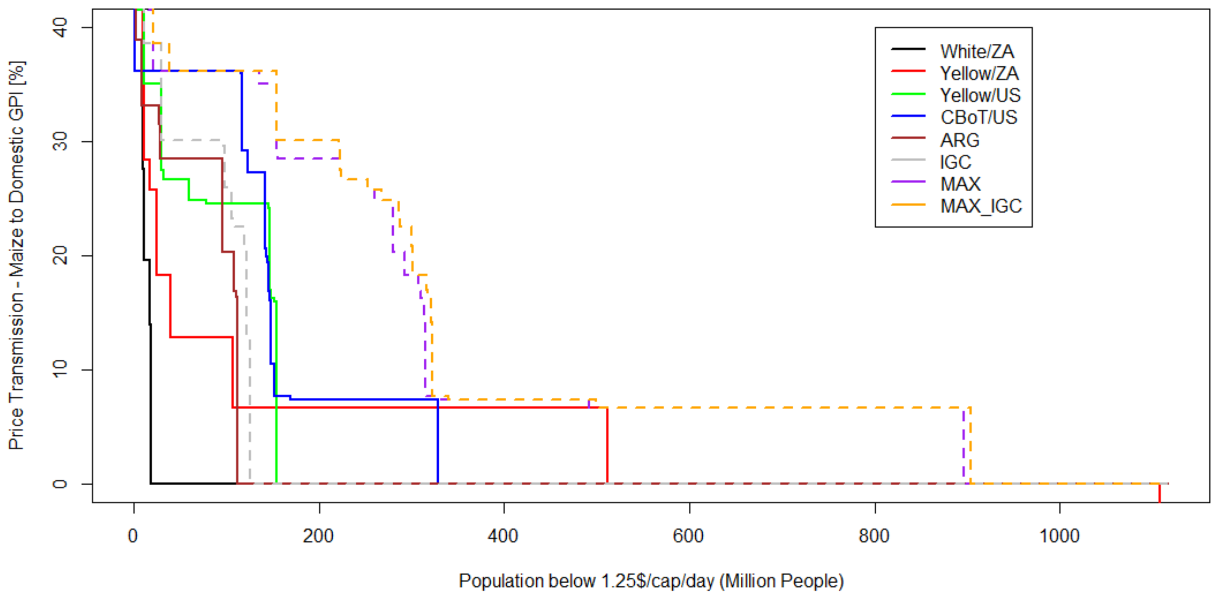


Figure 11. Transmission from several international rice prices to the domestic grain price index and affected people.

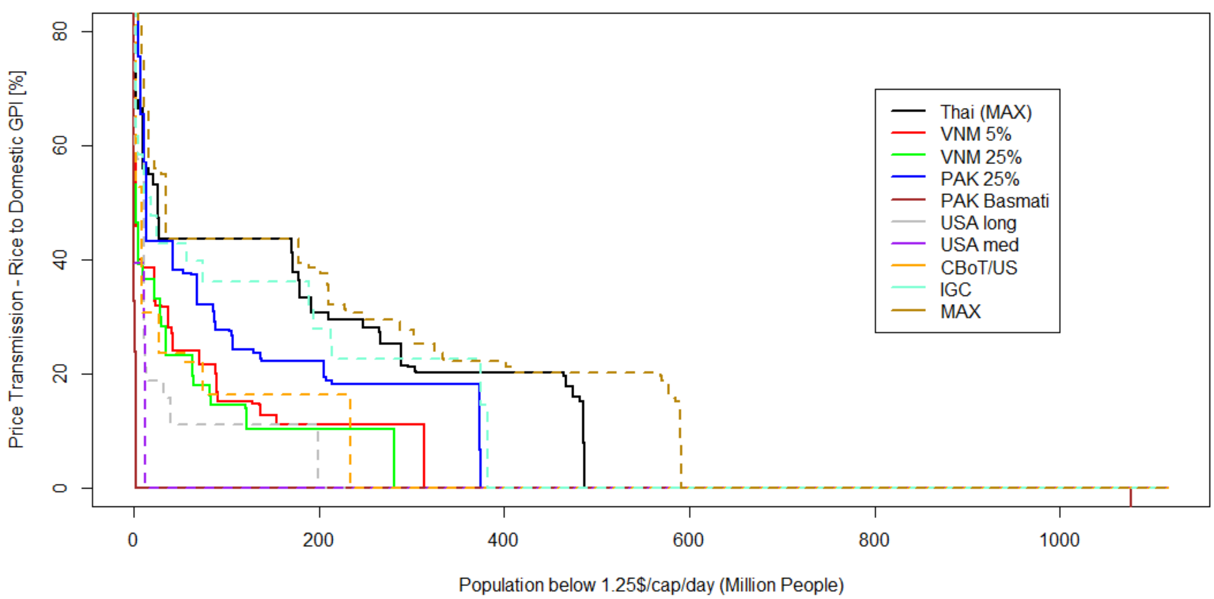


Figure 12. Transmission from Thai rice prices (export) to the domestic grain price index and affected people.

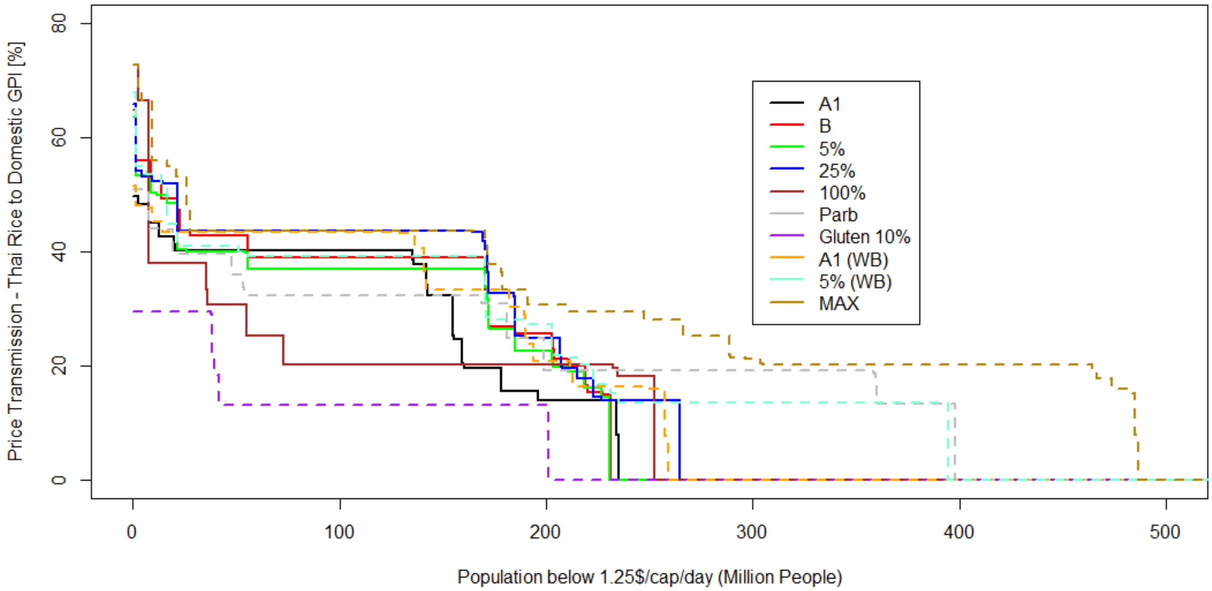


Figure 13. Transmission from several international oilseed prices to the domestic grain price index and affected people.

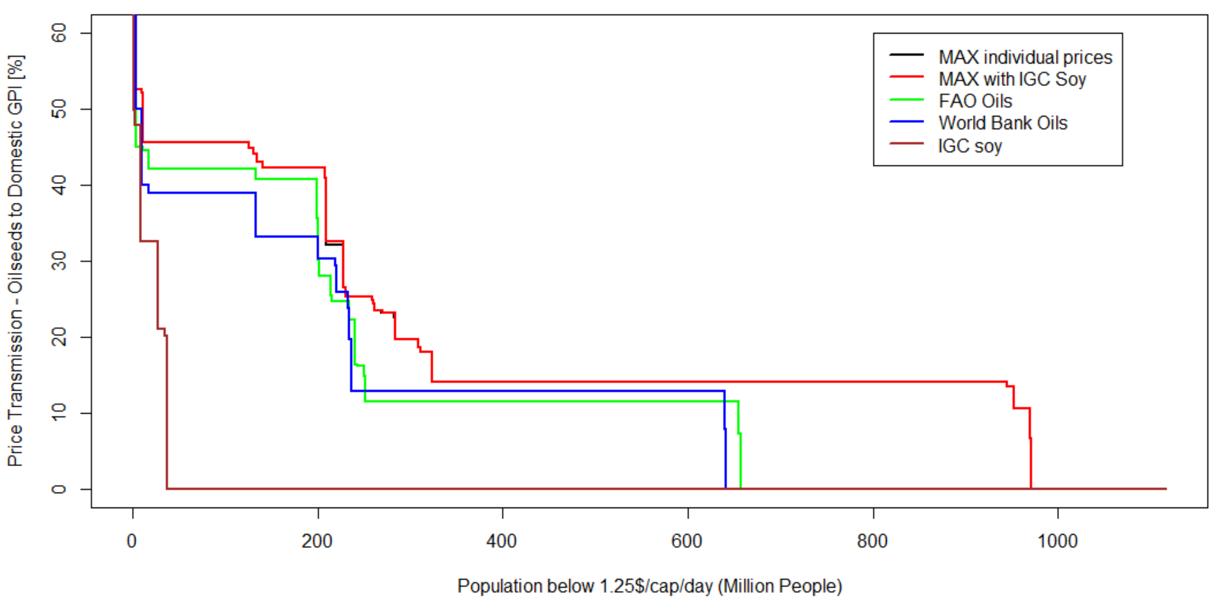


Table 4. Transmission elasticities of grain prices and price indices to domestic grain prices for countries with more than 1 million people below the poverty line.

ISO3	Poor Pop (Mio)	Wheat	Maize	Rice	Max (grains)	Max (US cereals futures)	FAO Food	FAO Cereals	WB Grains	IGC Grains/ Oils
AFG		0.30	0.46	0.37	0.46	0.28	0.71	0.52	0.50	0.51
BDI	8.0	0.00	0.26	0.16	0.26	0.00	0.00	0.00	0.00	0.00
BEN	4.8	0.28	0.00	0.55	0.55	0.00	0.00	0.00	0.00	0.00
BFA	7.3	0.00	0.00	0.28	0.28	0.00	0.00	0.00	0.00	0.00
BGD	66.9	0.15	0.30	0.22	0.30	0.15	0.76	0.33	0.00	0.31
BRA	12.2	0.31	0.22	0.40	0.40	0.00	0.61	0.36	0.39	0.35
CHN	159.4	0.10	0.07	0.23	0.23	0.16	0.42	0.32	0.32	0.00
CIV	4.7	0.00	0.00	0.67	0.67	0.00	0.00	0.00	0.00	0.00
CMR	2.1	0.18	0.21	0.00	0.21	0.17	0.00	0.32	0.24	0.29
COL	3.9	0.00	0.16	0.32	0.32	0.10	0.22	0.18	0.24	0.11
ETH	28.1	0.33	0.27	0.44	0.44	0.24	0.00	0.71	0.78	0.61
GHA	7.3	0.00	0.00	0.56	0.56	0.00	0.36	0.00	0.00	0.00
GIN	5.0	0.82	0.00	0.87	0.87	0.00	0.00	0.00	0.00	0.00
GTM	2.0	0.31	0.27	0.29	0.31	0.21	0.67	0.40	0.37	0.37
HND	1.4	0.00	0.71	0.81	0.81	0.42	0.00	0.65	0.78	0.77
HTI	6.3	0.31	0.43	0.58	0.58	0.53	0.86	0.56	0.59	0.57
IDN	40.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IND	404.1	0.11	0.07	0.00	0.11	0.11	0.19	0.00	0.00	0.00
KEN	18.7	0.27	0.25	0.31	0.31	0.31	0.00	0.41	0.35	0.00
KHM	2.8	0.00	0.00	0.81	0.81	0.81	0.74	0.00	0.00	0.00
LAO	2.3	0.27	0.00	0.19	0.27	0.00	0.00	0.00	0.00	0.00
MDG	18.1	0.19	0.39	0.25	0.39	0.27	0.42	0.38	0.34	0.40
MLI	7.5	0.12	0.00	0.24	0.24	0.12	0.00	0.00	0.00	0.00
MMR		0.27	0.25	0.27	0.27	0.27	0.00	0.00	0.31	0.34
MNG		0.55	0.37	0.32	0.55	0.34	0.88	0.69	0.53	0.64
MOZ	15.0	0.00	0.18	0.00	0.18	0.00	0.00	0.00	0.00	0.00
MWI	9.8	0.00	1.17	0.00	1.17	0.00	0.00	0.00	0.00	0.00
NER	7.5	0.00	0.00	0.21	0.21	0.00	0.00	0.00	0.00	0.00
NGA	114.8	0.36	0.36	0.44	0.44	0.36	0.00	0.00	0.00	0.00
NPL	6.8	0.31	0.00	0.19	0.31	0.00	0.00	0.00	0.00	0.00
PAK	37.7	0.29	0.00	0.29	0.29	0.00	0.00	0.00	0.00	0.00
PER	1.5	0.07	0.00	0.08	0.08	0.00	0.40	0.00	0.00	0.00
PHL	17.8	0.12	0.08	0.32	0.32	0.08	0.00	0.00	0.00	0.00
RUS		0.33	0.26	0.28	0.33	0.21	0.95	0.47	0.40	0.42
RWA	7.2	0.33	0.26	0.28	0.33	0.21	0.95	0.47	0.40	0.42
SDN	7.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEN	4.1	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.00
TCD	7.7	0.00	0.00	0.38	0.38	0.00	0.00	0.00	0.00	0.00
TGO	1.9	0.57	0.51	0.84	0.84	0.00	0.59	0.00	0.44	0.38
TZA	32.4	0.28	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00
UGA	13.8	0.21	0.00	0.00	0.21	0.00	0.43	0.49	0.45	0.00
ZMB	10.5	0.42	0.00	0.39	0.42	0.00	0.00	0.41	0.00	0.00
ZWE		0.00	0.00	1.54	1.54	0.00	0.00	0.00	0.00	0.00

Note. 'Poor Pop' refers to the number of people below the poverty line (estimated in 2012) – blank entries denote missing data. Wheat, Maize and Rice refer to the maximum transmission of the commodity prices at different international markets or of different types in each of the commodity group; max(grains) is the vulnerability indicator – showing the maximum transmission over the different grain prices; max(US cereals futures) is the vulnerability indicator over commodity prices at US futures exchanges. WB refers to the World Bank's grain price index.